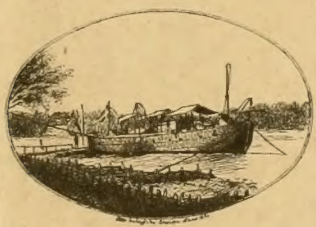
Report

of

The Danish Biological Station

to

The Board of Agriculture.



VIII.

1898.

By

C. G. Joh. Petersen,
Ph. D.

Kjøbenhavn.
Centraltrykkeriet.
1899.

From

The Danish Biological Station.

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An Otter-Seine

For the Exploration of Deeper Seas.

(With 10 Figures.)

By C. G. Joh. Petersen.

1898.

At a time when so many institutions, in Europe as well as elsewhere, are busily investigating the seas and their animal life, it will be a good thing to call the attention to improvements on the fishing-gear employed in this undertaking. As my experience in these matters have, presumedly, led to such improvements, I shall here mention them more closely.

It was almost a matter of course that the naturalists by their deep-sea investigations at first imitated the fishing-apparatus used by the fishermen: the *dredge*, for instance, in all its many forms, is certainly an imitation of the oyster-dredge, and like the latter calculated only to catch smaller and not very

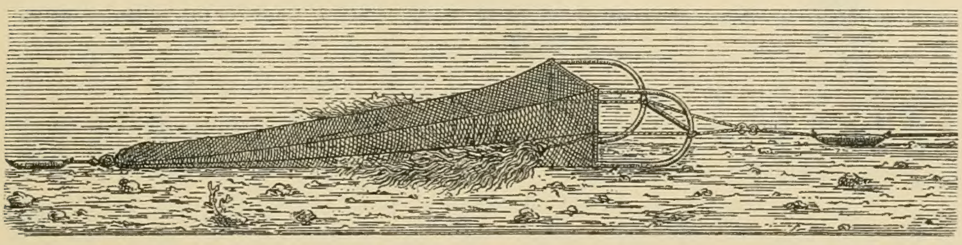

Fig 1. **A double-trawl.** (After the Prince of *Monaco.*)

quick animals; the *trawl*, on the other hand, was introduced just to catch the larger and quicker animals. This also is originally an imitation of the fishermen's trawl, particularly the *beam-trawl*, but in two things, nevertheless, the »scientific« trawl differs from that of the fishermen: *it is much smaller*, and it is usually *double*, i. e. made in such a way that it can fish whether it falls on one side or on the other (fig. 1). It was the Americans who introduced the

double-trawl, and it was long considered a great improvement on the ordinary single beam-trawl, which may sometimes fall on the wrong side, and is then incapable of fishing anything. It is a drawback, however, to the double trawl that its fishing opening generally can be only half the size (height) of that of a beam-trawl of the same width, and that its mouth during the dragging in is more dilated, so that the water will rush through it and spoil the finer organisms. Moreover, compared to the single beam-trawl, it is said to be objectionable on hard bottom, because its »fishing-ropes«, the ropes which scrape along the bottom, are so tight that they often take hold suddenly and burst. When we see, finally, that *Z. L. Tanner*, North-America's most experienced explorer of the deep-sea, in his recent description of the apparatus used onboard the »Albatros« (Bull. of the United States Fish Commission, vol. XVI. 1896, p. 357) says that the investigator always, with few exceptions, will be able to make the single beam-trawl (fig. 2) fall to the bottom in the right way, even on the greatest depths, the double trawl (the *Blake* trawl, *Agassiz'* trawl), presumedly, will scarcely be used in future, except when, from various reasons, it is impossible to employ any other fishing-gear. It must be granted that it has been of great service to science; many unknown animals have been caught by it; but it is a fishing-apparatus which differs much from the traditional one, i. e. from the trawl used by the fishermen in their daily work. We must remember also that a fishing-apparatus in such general use as the English beam-trawl represents the experience acquired by many people through long times and with huge labour; and we should not without cogent reasons give up a thing which has been approved by experience. An Englishman would hardly have ventured to do so, and it is scarcely accidental that it was an American who did; for in America trawling is not known in professional fishery.

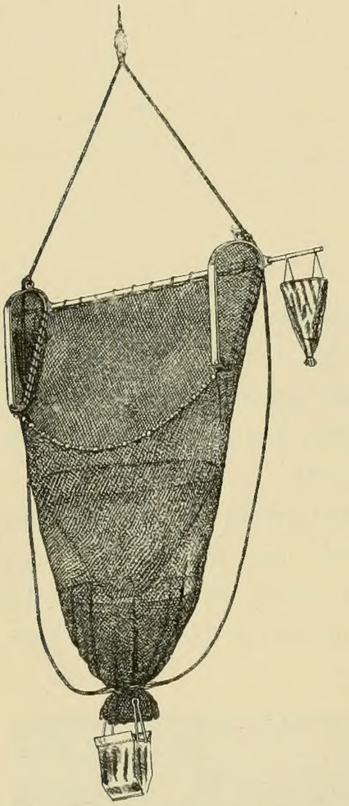

Fig. 2. **A single beam-trawl.** (After *Tanner*.) — The length of the beam is 11 Engl. feet.

In America, however, where scientific deep-sea investigations are carried on regularly, they have, as we learn from the report (1896), partly returned to

the *single beam-trawl*, which is almost similar to that used by the fishermen; but it is remarkable that, although the American exploring vessel compared to an English steam-trawler is a very large ship (234 Eng. feet long and more than 1000 tons of deplacement), its trawl is only 11 feet wide (the beam 11 feet), while the trawl-beams of the English trawls are as long as 40—50 feet. That the trawl for scientific use must have somewhat smaller meshes, and must be calculated to be sunk to greater depths than the fishermen's trawl, cannot quite explain the disproportion of the size of the trawl to that of the ship, at any rate not when the depths are not too immense. The soft bottom-material, certainly, may be gathered in considerable quantities in a trawl with small meshes, and thus make it heavy; but this difficulty might be overcome. I cannot quite understand why the large vessels which have carried on scientific investigations in the seas, at places where they are able to fish, have not used trawls at least of the same size as those used by the fishermen. It must not be imagined that such trawls would not catch any other animals than the small trawls. All zoologists would be most anxious, certainly, to see a draught of fish by large trawl on deep water; and they believe, all of them, that the large and quick animals, fish as well as cuttle-fish and large crustacea, make their escape as soon as they feel the proximity of the ordinary, small fishing-apparatus. We must go on, therefore, in this direction, and have larger fishing-gear; and I should think that the leader of the next deep-sea expedition would do well in going onboard a modern North-Sea trawler and study her method of fishing, *for in recent years a change has taken place here in the construction of the gear, which will certainly be useful also to science.* — What all deep-sea expeditions have been afraid of is, I dare say, the large *trawl-beams,* which it is no easy matter to manœuvre in a heavy sea, or in vessels that are not especially built for them; but now lately, in the course of these 3 or 4 years, the fisherman has just learnt to do without the beams, and yet he can fish better than before. His trawl has now an opening of 80—90 feet, while it was formerly 40—50, and at the same time his gear is cheaper, it is easier to use, and it fishes better than before. The beam is done away with, and *two slanting wooden otter-boards mounted with iron on the nether part, stretch out the trawl while sailing, so that its opening can be made as large as you want it; and yet the gear will not be much more difficult to manage above the water.* — This is the new so-called »*Patent Beamless Trawling Gear*« or »*Otter-Trawl*«. With respect to this gear the Danish Fisheries Agent in England says in his report, 1895, as follows: «This year a great revolution has taken place in the English trawl-fishing. The beam-trawl has been replaced by a so-called otter-trawl. A Dane,

who has been trained up in the English trawl-fishing, has constructed a trawl which, instead of being kept open by a heavy beam, is kept open by means of two iron-mounted wooden boards, which stand erect in the water, fastened to the vessel by cables of steel-wire, and which, by the speed of the vessel, remove from one another and thus keep the net open«. — »The new trawl has quite replaced the beam-trawl among the steam-trawlers in Grimsby and Hull, and even in Belgium and Germany it is now being introduced.« As to the whole historical development of this matter with respect to the professional fishermen I shall refer to a note by *J. Spillmann* (illustrated by *H. Giebel*) in »Mittheilungen d. deutschen Seefischereivereins 1896« pp. 151—156. According to this, a Dane, Captain *Nielsen*, of the Danish fishing-steamer »Dania«, has first understood to use the otters in the right way. —

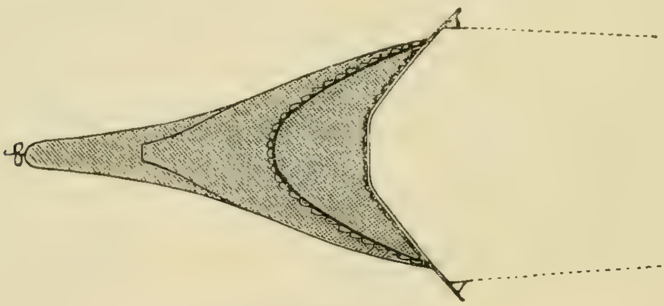

Fig. 3. **The English »Otter-Trawl«.**

When this trawl has not become general till these latter years, though we have also before known »otters«*) i. e. boards for the spreading of the net, one reason among others is that they cannot well be used without steam, and it is not till quite lately that we have introduced steam-trawlers. This gear is certainly the »best« our time knows of — the fishing-apparatus which is most terrible to the fish. A haul with it, of 4—6 hours, as it is usually made, but out on the greatest depths, will certainly, with a little good luck, give as many fish as an ordinary deep-sea expedition generally brings home. Such an otter-trawl (or »Skovl-Travl«, if you prefer that name) is dragged by the fishermen, however,

*) English *Otter*, Norwegian *Oter*, and Danish *Odder* is the same word employed figuratively of a somewhat older fishing-apparatus used in fresh water. A wooden board of the same construction as those of the trawls is here used to stretch out a line with hooks from a boat while sailing. This gear has been called otter, because it fishes so well. A trawl with two otter-boards was then called otter-trawl; but I think the Danish Skovl-Travl or Skovl-Vaad is a better name, and this has been used also in Denmark for some plaice-seines with boards, employed by the fishermen in the North Sea. — The seine described in this paper is a eel otter-dragseine.

in two lines, one line for each otter, and is used only on depths up to c. 100 fathoms; on greater depths it has been necessary to make other arrangements, to which I shall afterwards return.

In all the years I have been the Director of the Danish Biological Station we have never had occasion to make deep-sea investigations. The Danish seas are shallow, and the fishing is generally limited to depths under 10 fathoms; there we can easily manage otherwise. Not till 1897, when the investigations were to be carried on in the Skager Rack as also, at the request of the Norwegian government, in the deep Christiania Fjord, I must make arrangements for going deeper — as deep as 2—300 fathoms. My first thought was then to use our *ordinary eel-dragseines* for this fishery, in a similar way as that in which our fishermen use them at several places, i. e. with a beam which extends them and which indeed gives them a great resemblance to the beam-trawl. (Cmp. *Drechsel:* Oversigt over vore Saltvandsfiskerier. 1890. Pl. XV. A.) The eel-dragseines are so common in Denmark; every detail of their construction is so well known by our eel-seiners; the fishing capacity of the gear is splendid, nay, quite notorious, each and all characteristics which made me choose this apparatus instead of trying to make a beam-trawl. For there are not many here, at any rate none that I know of, who are able to construct a beam-trawl correctly in all details; moreover, the fishermen of the Biological Station are not practised in the use of such a gear which, be it remembered, is forbidden by the Danish law.

Now, I do not mean to say that it would be difficult to us (to my men and myself) to make a beam-trawl, which everybody who is not an expert in these matters, whould consider a very good beam-trawl; but it is a most difficult thing to teach oneself a quite new way of fishing, and it takes such a long time to do so, particularly if the fishing is to be carried on further than to the very first stages, that I thought I ought not to commence it without cogent reasons, more particularly so, as I knew that the time which could be employed for this purpose onboard a steamship was but very limited.

Nothing would have been easier, of course, than to order a suitable trawl from England; but this would not by far have cleared the matter. For even if such a trawl was in perfect order to commence with, and well calculated for English conditions, it would very soon be changed by use, and if you do not know by experience what is the matter, but have to make it out for yourself, you must be prepared to get a troublesome work, which will take you long time.

There are those who will say perhaps that these things are trifles. If the

gear can fish, then it is all right, and it is all the same whether it is made in one way or another. I thought so myself formerly. But 15 years' work has taught me something else: by studying the use of our various sorts of fishing-gear, by personally fishing with them, by having in my service and talking these matters over with some of our most intelligent fishermen, I have learnt that there can be an immense difference in the fishing capacity of fishing-gear which, superficially examined, looks alike: one apparatus has little faults in the construction while another is made as it should be. All of them can fish something, that is true; but the more difficult fish, eels for instance, are not to be caught by any seine, even though the meshes are small enough. — I still remember, though it is more than 12 years ago, the pity with which the fishermen sometimes looked at my first fishing-gear, among other things just a little double-trawl. They were right, in as far as such gear should be used only, if we can use no other, or if we do not care particularly to catch large, quick animals; but we cannot pretend with such gear to thoroughly investigate the stock of fish in the sea. If we will make fishing-gear, we must learn the trade, go through our apprenticeship, just as well as, for instance, a tailor must learn his trade; tradition and fashion are of great consequence to both crafts. When I particularly mention the trade of a tailor, it is because I here find so many similarities. A seine must have no other folds than those necessary, or the current that runs through it will be influenced disadvantageously, and the fish will take the alarm. The whole form of the gear must be correct, without the slightest obliquity, etc., and we cannot see its form till we try it on, i. e. till it is placed in the water; not till then, by floats and weight and the pressure of the water, it gets is proper form. One seine can »fish«, another one »cannot fish«, says the fisherman; and the fishermen have a thorough knowledge of all details which are here of any consequence, rarely written down, but generally enherited by tradition from generation to generation.

It will now be understood, why I selected a Danish fishing-apparatus, the *drag-seine*, for fishery on waters of a somewhat greater depth. As above mentioned, we tried it first with a beam; this, however, proved to be unpractical. The fishermen can easily use it with a beam on 3—4 fathoms of water, because they let the beam float in the surface; there will be no danger of its turning round. But on deeper water, where the fishermen never come with eel-seines, the beam must under the water, and then the difficulties appear. The beam of 12—14 feet in length was soon abandoned, and two otter-boards from *Plymouth*, which I happened to get possession of, were employed to extend the arms of the seine. It appeared that the eel-seine in this way very well could be used like

an ordinary otter-trawl. By certain winds it could be dragged on low water by a small sailing-vessel of 4—5 tons, and it fished a great number of fish, among others many eels, which are considered the most difficult fish to catch.

Two *otter-trawls,* made in this country for these very two boards, proved, on the other hand, to be failures, whether now this was owing to mistakes made by the constructors (one of them had been to England and was said to understand the art very well indeed), or the reason was that we did not understand how to use them. The *drag-seine,* however, fished well. It was dragged

Fig. 4. Sailing-vessel with otter drag-seine, belonging to the Biological Station.

in two lines, one for either »otter«; but I soon discovered that it was as well to drag it in a crow-foot, from the vertex of which only one line passed onboard the boat. (Cmp. fig. 4.) We were now able, by only making this line long enough, to drag with the seine *on any depth,* if we had only sufficient power to drag it.

A problem on which I had been pondering for years — how to employ an eel-seine from a steamer on water of greater depth — was thus solved, and we have got a fishing-apparatus which is eminently calculated to catch the livelier animals on deep water. Moreover the gear has small meshes and is therefore able also to catch smaller fish. With ordinary, suitable speed it is extended to about 12—16 feet, and it is thus at least as large as the usual trawls employed by the greatest vessels for deep-sea investigations; yet it is so easy

to manage that I have been able to use it from a steam-launch (32 feet long) on a depth of 30—50 fathoms; and had not a steam-winch been wanting for heaving-in the wire-ropes, a powerful steam-launch would be able to manœuvre it, and use it with profit, on a depth of several hundred fathoms.

With such an apparatus, an *eel drag-seine with boards,* I have this summer made many hauls on depths between 1 fathom and 300 fathoms. After the first difficulties in finding the suitable speed, boards of suitable size and weight, crow-foot of suitable length, etc., had been overcome, the gear has worked excellently. I have, in 1897, employed it from no less than 7 various steamers of very different sizes, as also from a sailing-vessel, on very soft as well as on hard, partly stony bottom in the Cattegat, the Skager Rack, and in several Scandinavian fjords, for instance the Christiania Fjord, and it has never been quite torn to pieces.

In the following the details of this fishing-gear will be more closely described; first, however, I must make a historical observation. —

Besides the *beam-trawls* which have been used on the various deep-sea expeditions, the size of which (the length of the beam) was, for instance, on »*Vøringen*« 15 feet, on the »*Albatross*« 11 feet (*Tanner* beam-trawl), the »*Blake*« 10 feet, the »*Pola*« c. 10 feet, etc., the Norwegian north-Atlantic expedition in »Vøringen« has also made use of a small *otter-trawl*, and just in the same way as I employed the eel drag seine, i. e. *with a crow foot.**) This otter-trawl, however, was but very little used in »Vøringen«, not because it could not catch anything, but because it so often became foul when it was placed in the water. Twice, however, they succeeded in getting it out clear, and both times the result was excellent, a great number of fish being caught. The gear is mentioned only very briefly in the report, and a picture of it is given, but in such a way that we cannot form any clear conception of its real form. It is no easy task to picture and describe seines and trawls accurately — I grant that — but we do not get over the difficulties by pretending not to see them,

*) I Scotland they have on various occasions made use of larger beam-trawls in fisheries for practical-scientific purposes, on a depth of as many as some hundred fathoms. As far as I remember, the beams were c. 20—30 fathoms long; but on the greater expeditions they have always been much smaller. — The fishing-gear from the French expeditions in the »Travailleur« and the »Talisman«, which have caught an unusually large number of fish, is mentioned in »Annales hydrographiques«, 2. Ser. T. V. 1883, pp. 24—25 and p. 281, as also loc. cit. 2. Ser. T. IV. 1882, pp. 385—398, particularly p. 389. It seems as if they have first (in the »Travailleur«) made use of a large trawl with a beam 7 meters long and then afterwards (in the »Talisman«) changed this for a »Blake-trawl« of 2—3 meters. — The reason for this is not stated.

and this, with few exceptions, has been the usual custom. Among these exceptions must be mentioned *Tanner* and *the Duke of Monaco*, who with his proportionally small vessel, the »*Hirondelle*«, has done much, and particulary paid great attention to the apparatus, of which several new ones have been constructed, particularly *deep-sea weels* (traps) and an *otter-trawl* for pelagic fishery which in its construction with crow-foot and boards very much resembles the one I have used; the net-apparatus, however, is quite different.

We must not lay too much stress, however, on the unsuccessful experiments which »*Vøringen*« made with otter-trawl or rather, I think, with otter-seine; for if we have no practice in the use of such a one, and if the vessel, as the case was with »*Vøringen*«, is rather large in proportion to the trawl, the fishery will easily turn out a failure, particularly in unfavourable weather. Here as everywhere some practice in necessary. The first times we tried to place an *otter-seine* in the water, we failed nearly every second time; since then I have personally manœuvred the steamers, and made more than 100 hauls on all depths, down to 200 fathoms, without a single failure from that reason. The principal thing is, all the time while you are lowering the gear, to hold the line so taut that the boards are constantly removing from each other, a thing the man who veers out the line very quickly learns; at the same time, of course, the vessel must go on by the propeller. When the length of line you want to get out, is out, the speed is diminished so much that the seine is allowed to sink slowly to the bottom. — On these depths, up to 2—300 fathoms, I have found it superfluous to use an accumulator for the tow-rope, which of course was of steel-wire; in a high sea it will be necessary, however, if there is anything heavy in the seine. The wire-rope has during the dredging been fastened round the trundle-head of the steam-winch, so that we were able, if the seine should take too firm a hold of the bottom, to veer away and then heave in. The tow-rope has during the trawling always gone astern, either through a jaw on the stern-sheets, or, and that is the best, along the side of the ship, over the bow, through a short, strong davit, or the like. (Cmp. fig. 5.) In the latter case the rope has, during the fishing, on the short vessels, been hung up and made fast under the buttock, so that it could not get into the propeller. When they are to heave in, they let go from the buttock, and the vessel swings to the seine while they heave in — provided that the vessel is not too large in proportion to the seine. For the sake of the manœuvring as also in order to get a suitable speed, for the sake of the fishing itself consequently, there should be, evidently, *a suitable proportion between the size of the vessel and that of the seine. The ship should feel that it has something to drag,* or the speed will easily

be too great and, where you can see no land, difficult to judge of, particularly when the weather is unfavourable.

To lift the whole seine up over the water, as they do by the usual deep-sea investigations, by letting the tow-rope go through a block *high up* in the rigging, so that the whole apparatus, while it is taken in, is floating in the air, stretched out, is against all good fishing-practice, and is, moreover, almost

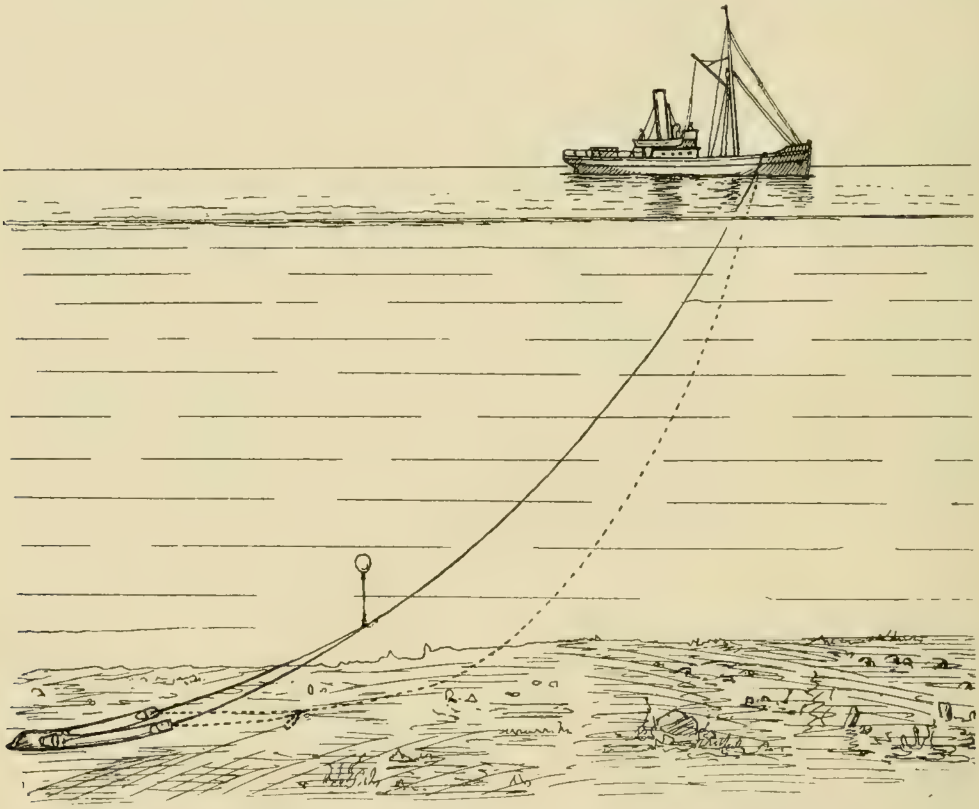

Fig. 3. **A small steam-boat with an otter-seine.** — The dotted line marks the disadvantageous situation of the gear, when the crow-foot drags along the bottom. — The depth of the water is somewhat great in the figure in proportion to the length of the line.

impossible with this long apparatus. The rolling of the vessel will also influence the gear much more during the hauling up, and an accumulator will then certainly be quite indispensable; moreover, if the contents of the seine should be very heavy, the seine may be torn to pieces by being lifted out of the water in this way. The tow-rope must not be fastened much higher up than the rail, and the seine must ultimately be hauled in by hand till the strong bag is so high up that you can pass a strap round it, and bouse it in, if necessary. First, however, you wash out, by backing or going on with

the vessel, as much mud as you think fit. In short, you do just as a trawler when he takes in his trawl. On a very soft bottom, particularly where there live many *Brissopsis* or *Echinocardium*, the seine may be filled with bottom-material. This can be avoided by fastening an old, flexible, and thick coir-rope (2—3 inches in diameter) to the foot-rope. — I think it superfluous here to enter into the details of many other things which must be taken into consideration while trawling: the direction of wind and current, etc. (As to this cmp. *Tanner:* Deep-Sea Exploration. Bull. U. S. F. C. Vol. XVI. 1896. pp. 390—95). —

The otter-seines I employed consist, as to net-apparatus (cmp. fig. 6), of two arms, each of them 300—340 meshes long and in their whole length 100

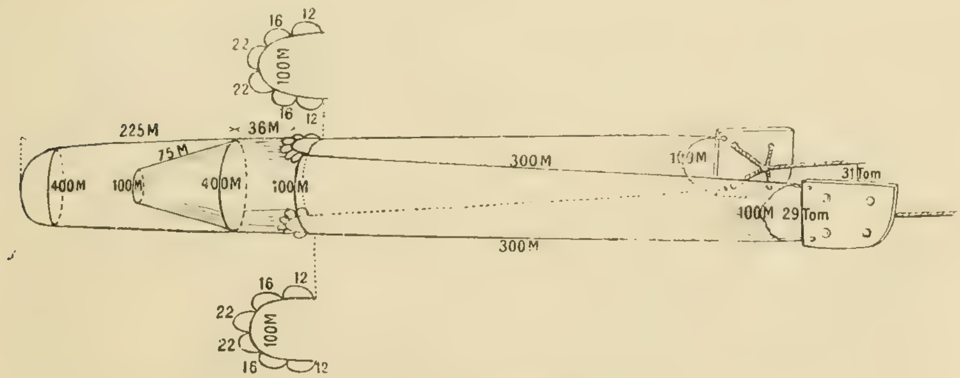

Fig. 6. **The otter-seine employed by Petersen.**
M. means meshes. Tom. means Danish inches. — Each arm is c. 24 feet long and the bag c. 16 feet.

meshes deep, fastened to the *bag* (at *the mouth of the seine*). The bag consists of a forepart and a hinderpart, and contains a pocket fastened to the hindmost border of the forepart of the bag. The forepart of the bag is 36 meshes long and 400 meshes in circumference, all through. The foremost border adjoins either arm with 100 meshes; of the remaining 200 meshes (100 above and 100 below) 100 are sewn on to two feet of, respectively, head-rope and foot-rope, exactly the same for both, and, as shown in the figure, with 6 »hitches« (12, 16, 22, 22, 16, 12 = 100 meshes on 2 feet of the rope). By this the bag becomes somewhat puckered above and below, but smooth by the arms.

The pocket, which in front is 400 meshes in circumference, is sewn on to the hindmost border of the forepart of the bag (consequently 400 meshes); it is funnel-shaped, 75 meshes long and 100 meshes in circumference in the hindmost, detached opening.

The hinder part of the bag is c. 225 meshes long and 400 meshes in

circumference, all through; but, if we want it, a narrower end-piece may be added (Cmp. fig. 6). The bag is open in one corner only, and can there be closed with a tie.

The pocket can be put together of two machine-tied pieces; but generally it is tied by hand, of light, strong, fine cotton yarn, as it must be very easily movable in the water. If it is hand-tied, it is necessary to »narrow« in it; *otherwise there will be no narrowings at all in the whole seine,* and it can therefore easily be made of square, machine-tied pieces of yarn.

The *arms* and *the forepart of the bag* have meshes which, stretched out, are c. 20 mm long (40 mm in circumference); the meshes in the pocket and the hinder part of the bag are 16 mm long (32 mm in circumference); the thread is everywhere (except in the pocket) 9-threaded cotton No. 12.

A still narrower part can, as above mentioned, be added to the bag, for instance of meshes of 11 mm (22 mm in circumference); but this depends on the use you want to make of the seine. —

The meshes of the arms are sewn on to the ropes (alike for both), head-rope and foot-rope, in such a way that, on the half-part nearest to the mouth, 6 meshes are carried in on each »hitch« of 4 meshes' length, i. e. on 80 mm; and on the outer half 6 meshes on each »hitch« of 86 mm. The length of the bag becomes c. 16—18 feet.

The ropes are of equal length, c. 24—28 feet; but the lower one must be much heavier than the upper one, for instance 3—3½ inches round, and both had better be made of loosely laid rope, so that they do not kink. The whole apparatus must stand quite smooth in the water, particularly the arms near the mouth, without any puckers from above downwards; in the bag, by the mouth, on the other hand there will come many puckers lengthwise. Accuracy in sewing the meshes on to the ropes is most necessary, and if the latter become longer by use, the net must be unsewn and sewn on again; particularly if the ropes do not stretch equally much.

In order to give the seine the correct position in the water, weights are attached to the foot-rope, and floats to the head-rope. The greater the weight is, the harder the rope will drag along or in the bottom; the more weights, the more equally the gravity will be distributed. I have found ca. 39 little stones suitable, in *straps* of 2—4 inches in length. The distance between the stones at the mouth must be a little shorter. At first we used a float made of wood, c. 40 little pieces; they must be placed near the mouth, so that the latter can be lifted up well in the water; afterwards I have only used float-glasses (the Norwegian floats), and no doubt it will be right *to use float-glasses*

only as floats; they can bear the pressure of the water even down to 3000 fathoms (cmp. *Tanner,* loc. cit. p. 355), and do not change their specific gravity, such as wood or cork, which already on a depth of a few fathoms is pressed full of water, and so looses its power of lifting the net. Each glass-balloon can bear about $^1/_2$ lb. of lead in the water, and I have found it suitable to put on just so many balloons that they can bear the *weight,* which is tied on, *in the water.* The seine will then sink on account of the net itself and of the boards.—

It is a most important thing that the seine is well balanced, and balanced to fish on that bottom on which we want to use it. It is apt to be too heavy, so that it gets filled with mud. (See *ante,* however, p. 13, as to the use of a coir-rope). With glass floats, tied up in meshes of spun yarn, the balancing can very easily be managed on shallow water, and the whole apparatus can there be properly arranged. Its specific gravity will then not change perceptibly on the great depths, as with cork or wood. I have found ca. 30 glass-balloons, and a weight of 14—16 lbs. under water, suitable.

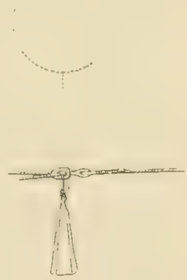

Fig. 7. The vertex of the crow-foot with shackle and lead to prevent twisting. — (The dotted balloon works to the same effect.)

The boards are made of deal boards, $^3/_4$ inch thick, with two long iron bolts through them. They are c. 29 inches high and 32 inches long, or longer. At first we used smaller boards, but these fish incomparably better. They are bound with iron below, so that they sink as quickly as you want them to. On account of the distribution of the weight (with iron below), they will remain in an upright position when they reach the bottom, and they always sink through the water upright, just as the arms of the seine. When they are suspended in the thimble which is placed in their four-branched crow-foot, they must point down a little with their *fore-end.* The ropes of the arms are fastened to the hind-edge of the boards in two holes, so that the arms sit on the *outside of them.* From a little in front of the centre of the boards the two bridles of the crow-foot proceed (Cmp. fig. 5—6.) The latter was made of wire, and each bridle was c. 8 fathoms long. At first we used a shorter crow-foot, but it is a great question *whether it ought not to be still longer.* (As to this, see farther on). In the vertex of the crow-foot is a shackle, in one eye of which the tow-rope is fastened. To prevent the bridles of the crow-foot from twisting together, as they are inclined to, a lead (of c. 5 lbs.) is fastened to the undermost, movable eye of the said shackle, so that it hangs downward in a short strap. This prevents the twisting (Cmp. fig. 7).

As soon as the bag and the arms have got into the water, and the boards

have been lowered, while the vessel goes on quite slowly, the whole apparatus immediately places itself in the right position, with the boards removed c. 12—16 feet from one another, so that you can see in the surface of the water, whether the whole apparatus is clear. When you then veer, in such a way that the tow-rope does not run out too quickly, the gear will always get clear to the bottom; if not, the bag may, when the arms are veered down over it, twist round the latter, or one board may fall down over the other. Such a thing, however, happened only in the beginning.

As above mentioned, I suppose that the boards, with the usual, suitable speed (about 1 knot), are 12—16 feet removed from one another. The seine, therefore, gapes as widely as the common trawls for scientific use, even in the largest vessels. The height of the mouth is c. 3—4 feet in the water, consequently considerably greater than in the said trawls (c. 2 feet). The length from the boards to the end of the bag is c. 40 feet, against a total length of 17—20 feet in the trawls, and yet this apparatus may be employed easily from the smallest steam-boat that can only tow it, or from a little sailing-vessel of 5 tons.

It would be desirable to compare the fishing capacity of the *otter*-seine directly to that of one of the common deep-sea trawls; but I have been unable to do so. The seine, however, has fished most excellently; on shallow water, for instance, lots of Eels, Cod, Whitings, various species of flat-fishes etc., and on deeper water, *Coryphænoides rupestris, Gadus poutassou, Gadus morrhua, Gadus Esmarkii, Merluccius, Argentina, Chimæra, Lycodes, Myxine, Rays,* large *Pandalus, Hippolyte, Nephrops, Pasiphaë, Nyctiphanes, Cuttle-fish,* and a great many other smaller, quick animals. But the thing which in my eyes is the most important in this matter, is, that the apparatus, without being perceptibly more difficult to manage, can be made still larger and consequently be able to catch much more, and to catch other of the quick animals which now escape it. For use in another year I have had a seine made which is a little larger in all the meshes and whose bag is 500 meshes in circumference, the arms, at the bag, being 120 meshes deep and 300 meshes long. — If we prefer the 400 meshes, as in the above described seine, it is not necessary, however, to make it exactly like that in order to get a seine that fishes well. The fishermen are said, for instance, often to make the arms 120 meshes deep, instead of 100; in this way the 6 »hitches« at the mouth are made smaller by 20 meshes, above as well as below. There is no small difference between the eel-dragseines in the various parts of the country with respect to the size and number of the meshes, the sewing on, etc., conditioned by the size of the

boats, the height of the vegetation, and so forth, but in their broad features they are very like each other in their general appearance and form. — If we choose to make the meshes larger, we can get a very large apparatus, which can be dragged with much greater speed and, consequently, fish much quicker and catch larger animals; and we are not troubled with clay, mud, and those smaller animals and shells which we, otherwise, are too apt to get. For be it remembered, *with a small-meshed apparatus, however large it may be, we can drag only very slowly.* With great speed it will drive the water along in a wave that washes away everything and frightens all quick animals, before they are within reach; small meshes necessitate slow sailing; with *large meshes we can and must go on with a good speed.* To keep the right speed is a very necessary thing, which requires great practice and experience. Indeed, for every new apparatus we must practise on low water, where the catch can easily be compared to that of the older well-known apparatus. Every fisherman knows how necessary it is to make a new eel-dragseine perfectly »fishable«, and I have heard the same said of the large English trawls. It holds good, probably, of any seine which is constructed with some fineness, and which is intended really to fish as well as possible. An ordinary dredge or a »scientific« trawl, on the other hand, can be used by everybody. They are extended by means of heavy iron frames, and are anything but »fine«. Yet, also here there are certain things to be observed; the claims to practice and experience in fishing-technicalities, however, are reduced to a minimum; their fishing-capacity is, accordingly, not very great. Nevertheless, we must not forget that great advantages are connected with them, on a difficult bottom and for certain purposes. A universal fishing-gear which is equally good under all conditions and for any fishery, is not known and will never be known; the dredge and the small scientific trawls, however, have been employed only too much as such.

It will have been observed that the here described otter-seine approaches very near indeed to the new English Patent Otter-Trawl; only, it is dragged in a *single line* with a *crow-foot*, which must be the case with the latter also, if they were to be used on deep water. The greatest difference between them, irrespective of a great number of details in the construction of the net itself, is, that the trawl has shorter arms than the seine, that its foot-rope is longer than the head-rope, and that its bag is tapering towards a point, while the bag of the seine is nearly of the same width throughout its whole length. I shall not attempt to discuss whether these differences are advantages or drawbacks, whether, in other words, we ought rather to make otter-trawls than otter-

seines for scientific fishery: for the time present I am able to make and to use the latter only. But supposing we want to keep the small meshes, c. 1 inch stretched out, $^1/_2$ inch square, and as a rule I think we do so, we have the advantage that the *seine in »practical life« has just such meshes,* while those of the trawl are much larger; and although, within certain limits, we

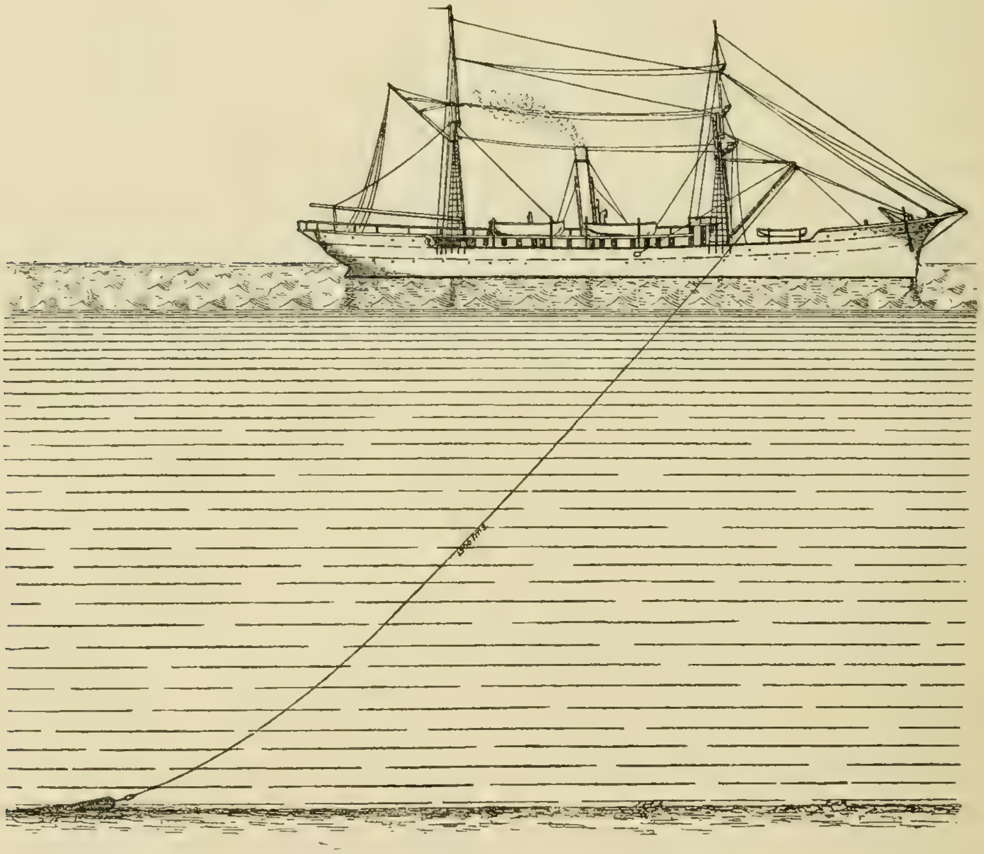

Fig. 8. **The Albatross** trawling. (After *Tanner*.)
(The tow-rope is shown lifted up from the bottom in its whole length; its most advantageous position.)

may change the size of the meshes in both gears, it is a great question after all, whether a seine will fish well with very large meshes and a trawl with small ones. If anyone wants to use a trawl, because he knows it better, there is thus scarcely any essential reason to prevent him. Yet, if the meshes become very small, I just call the attention to the fact that the bag of the seine is larger both in circumference and in length, and suffers larger volumes of water to pour through, than the pointed end of the trawl; and a great mass of water must be able to pass through, if the fish are to get in here, just

driven by the current. — The pocket is one of the things in the seine which must be shaped most accurately. It must be longish, funnel-shaped, without any folds, and with a mouth (at the farther end) which can be extended as more or less water runs through it. Therefore there must *not be any tie in the mouth* either, only meshes, which can be extended of their own accord, as the force of the water becomes greater while you go on. If you stop, the pocket must collapse, and so prevent the escape of the fish which are already caught.

A drawback to all sorts of fishing-gear on deep water is that the tow-rope, which is always of steel-wire, does not go directly from the fishing-apparatus up through the water to the vessel, as it is often *pictured* (see for

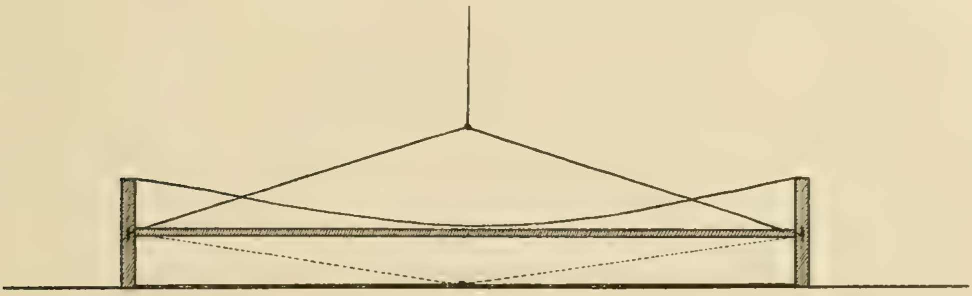

Fig. 9. **A Double-Trawl (front-view).**
The dotted line shows the crow-foot in the unfavourable position, the line fully drawn out shows the same in the favourable position. (About the same scale as fig. 10.)

instance *Tanner*: loc. cit. p. 365. & fig. 8); it is generally dragging along the bottom in front of the gear, putting in motion the loose mud, by which all shy animals are frightened away. (Comp. fig. 5.) Perhaps this matter has not been sufficiently considered, for I have nowhere seen it mentioned more closely. If we imagine ourselves standing in front of such a »scientific« trawl while it is working on the bottom, we shall see something like fig. 9 & 10, where the dotted lines show the crow-foot with shackle and tow-rope. We see immediately that the position of these lines is very unfavourable, as they bar a part of the fishing opening. On low water, 2—5 fathoms, where the vertex of the crow-foot does not touch the bottom, because we can here take care to veer out as little rope as necessary, the ropes sit, as shown by the fully drawn lines in fig. 8—10. The fish perceive nothing at all till they are between the arms of the seine, consequently till they are nearly caught; but on deep water when the vertex of the crow-foot touches the ground, the fish must swim over the bridles of the crow-foot before they get into the seine. The fishermen's

tow-ropes always stand in the favourable position, partly because they drag in two separate lines, partly because they come on lower water only (under 100 fathoms).

It is therefore, evidently, a matter of great importance to lift the crow-foot and tow-rope from the bottom, in such a way that they do not prevent the fish from getting into the trawl. I cannot say precisely, how it can be done on deeper water, but I shall mention some momenta which influence this

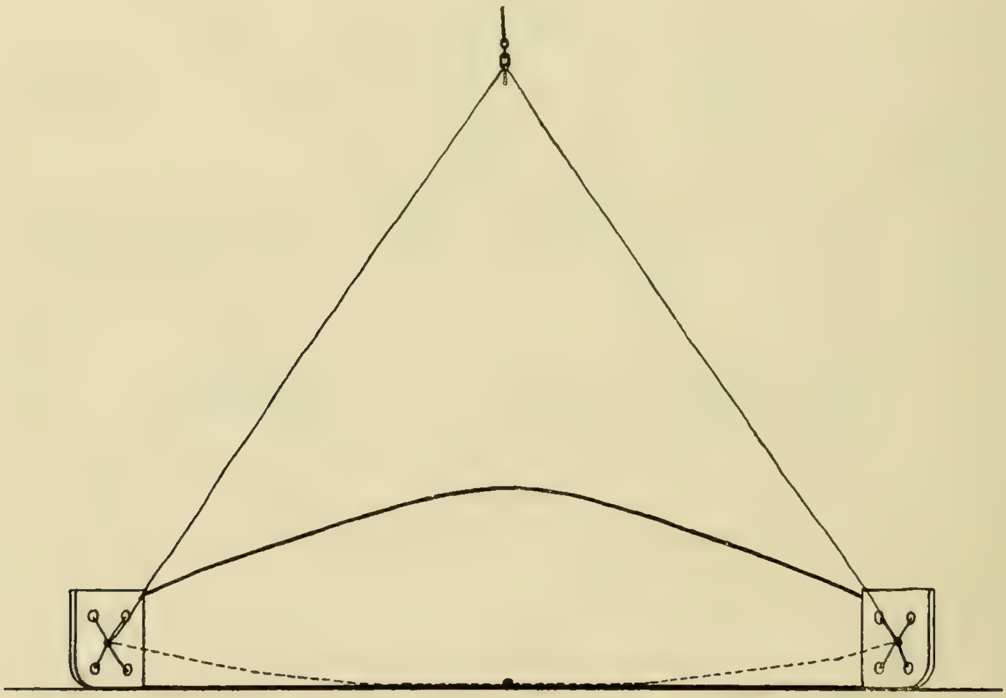

Fig. 10. **An Otter-Seine (front view).**
The dotted line shows the crow-foot in the unfavourable position, the line fully drawn out shows the same in the favourable position. (About the same scale as fig. 9.)

matter. If the otters of the seine are very heavy and the crow-foot with the tow-rope proportionally light, there will be a tendency towards lifting the latter two from the bottom, provided that we do not veer out too much line; and if we could make both bridles of the crow-foot very long, for instance 100 fathoms, we should, I dare say, within certain limits, be able to manage it in such a way that the vertex of the crow-foot never went to the bottom. But if we make the crow-foot too long, it is difficult to heave it in, and it is liable to twist together, because the angle between the bridles becomes smaller, the longer the bridles are; this twisting can be counterworked, however, as above

mentioned, by attaching a lead to the shackle (see fig. 7), but then again the whole thing becomes heavier. I have therefore, in 1898, counterworked the twisting by tying three floats of glass to the shackle, which by their upward pull evidently counteract the twisting as well as a downward pull. I imagine that we, after some experiments, shall be able to construct these floats in such a way that they actually keep the crow-foot in the turned-up position which we want. (Comp. fig. 7 [dotted] and fig. 5 [fully drawn out]). The difficulty is only to get the weight of the crow-foot and the otters duly apportioned — the former is to weigh but a little, the latter much — and to get a float of suitable size. Perhaps neither the crow-foot nor the first part of the tow-rope ought to be made of steel-wire, but of a material of a lower specific gravity. It is scarcely worth the while, however, to talk much of this as yet; I only set forth the thought for the further consideration of those who might be inclined to make experiments upon the matter.

As to the condition of the bottom, it is a well-known fact that it is of the greatest importance with respect to the applicability of the trawls and the seines. A sharp coral-bottom or sharp stones which tear everything to pieces, or take hold of the foot-rope in such a way that it cannot get loose again, make any such fishery impossible. If the stones are round or partly hidden in the bottom of the sea, the otter-seine may very well be used; it is pretty well adapted to get over such stones, particularly with a coir-rope (see *ante*), as it falls together by continued pulling, so that the otters approach one another. On a hard sand-bottom the otter-seine fishes excellently, also where the bottom is covered with *Zostera*. On a soft bottom (mud) you will always be able to drag with a »scientific« trawl; but whether it will go down into the mud and be quite hidden by this, or whether it will skim the surface as it ought to, is a thing you cannot know or decide beforehand; for its frame is and must always be heavy. By means of a coir-rope, however, you can always make the seine go lighter across the bottom, and owing to the oblique position of the otters they can never sink deep down, not even in very soft mud; also in this respect, in my opinion, the seine has a great advantage over the »scientific« beam-trawls. —

In concluding, I shall still mention a very important thing with respect to the use of such apparatus, i. e. their *preservation*. Our fishermen always use pure coal-tar for the preparation of their eel-dragseines, maintaining — and according to my experience they are right — that if the seines are not quite stiff with coal-tar, they cannot catch well. The pocket only must not get too much coal-tar; as above mentioned it must be light, it must take its right

position, in funnel-form, at the slightest motion of the water, and when the seine stops its progress across the bottom of the sea, it must collapse and so prevent the fish from escaping out of the bag; but the arms and the bag must be stiff with coal-tar, so that they will always stand up and make no folds.

The fishermen always employ *heat* for making the coal-tar thin, before the apparatus is dipped into it. According to my experience it is easier and better to make it thin by *mixing it with creosote-oil* (carbolinium). The tar can then be used cold, and enters better into the strands. When, by much use, the tar is worn away so far that the strands may become saturated with water, the treatment must be repeated. To prevent wear and tear where it is worn most, i. e. on the under side of the bag, an *extra* piece, made of yarn, is fastened to the outside, so that the bag here really becomes double; but it is necessary to sew on this piece carefully, so that it does not prevent the bag from taking its right shape in the water. —

As pointed out above, it is not my opinion that we shall rest satisfied with the here described apparatus for the investigation of the unknown seas; but I have wished to point out a way which has not hitherto been successfully trodden by any explorer, and which makes it possible easily to modify the apparatus with due respect to the various problems that are to be solved.